Eckerd College

on Florida's Gulf Coast

Radiation Destruction of Glycine under Astrophysical Conditions

Jan-Luca Bell (Eckerd College)

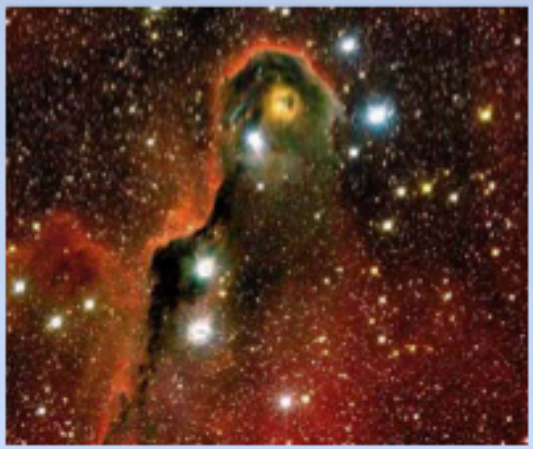
Dr. Reggie Hudson (GSFC, Eckerd College)

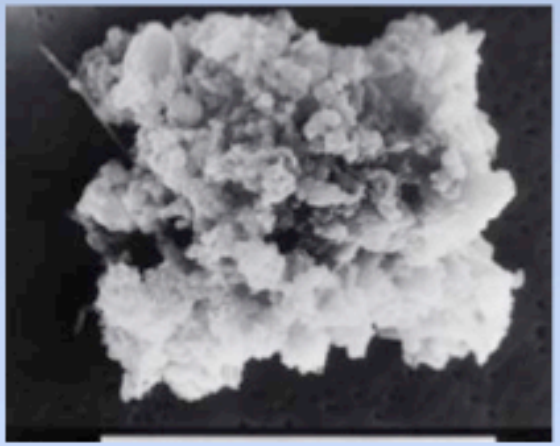
Dr. Marla Moore (GSFC)

Why Study Amino Acids?

Relevance of the study:

- Amino acids (AA) may have played an important role in the origin of life
  - AA have been found in Stardust sample return mission
  - Lab simulations have confirmed AA formation in environments in dense clouds
  - AA formation may also occur on icy satellites
- Ionizing radiation in all these environments



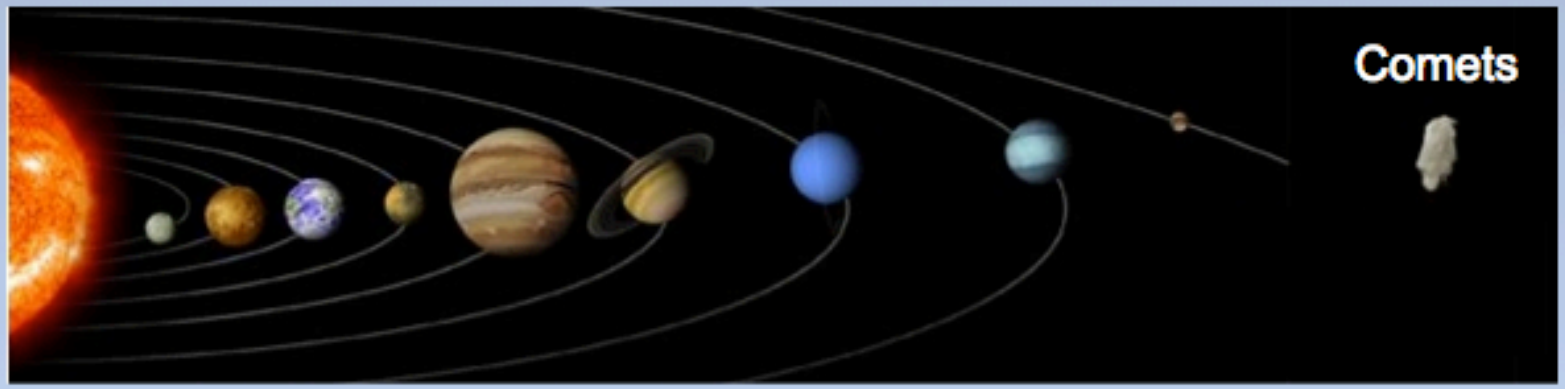


Radiation in Space

Solar Winds

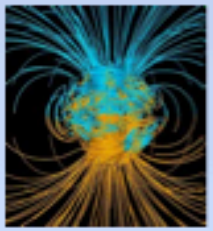
UV-Radiation

Cosmic Rays (p+)



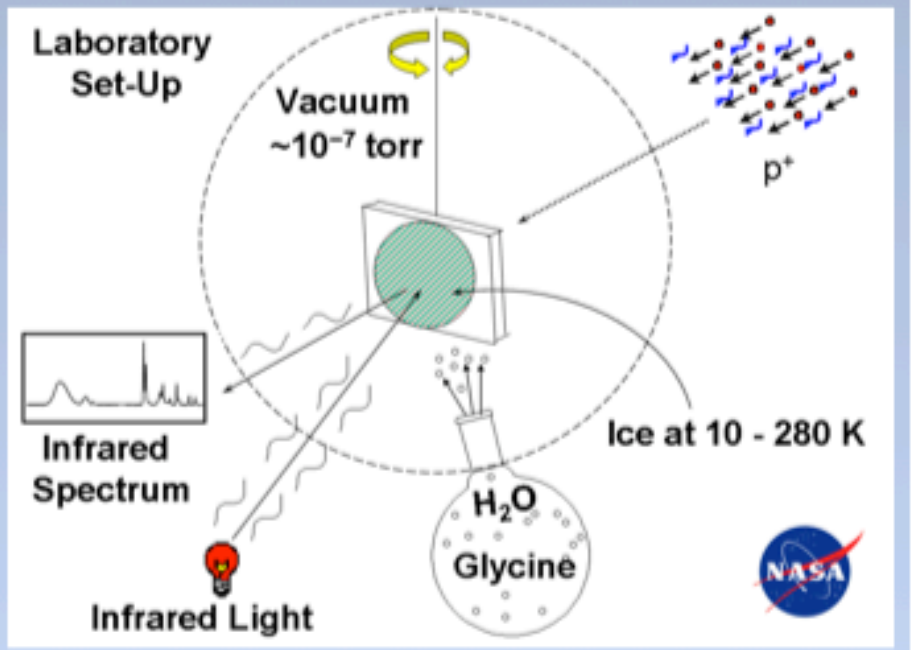
Magnetospheric >> Cosmic

Magnetospheric << Cosmic

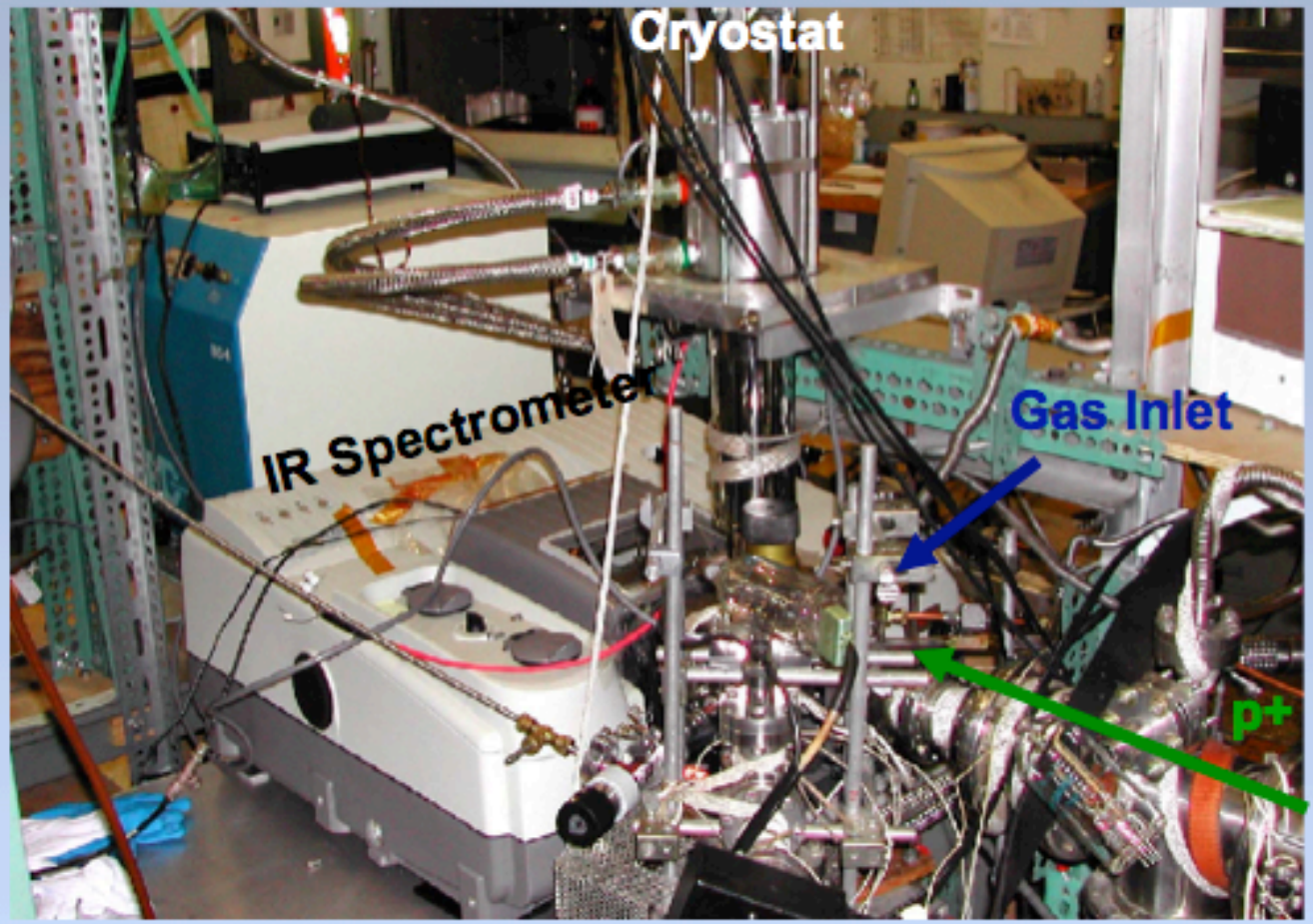


Experimental Methods

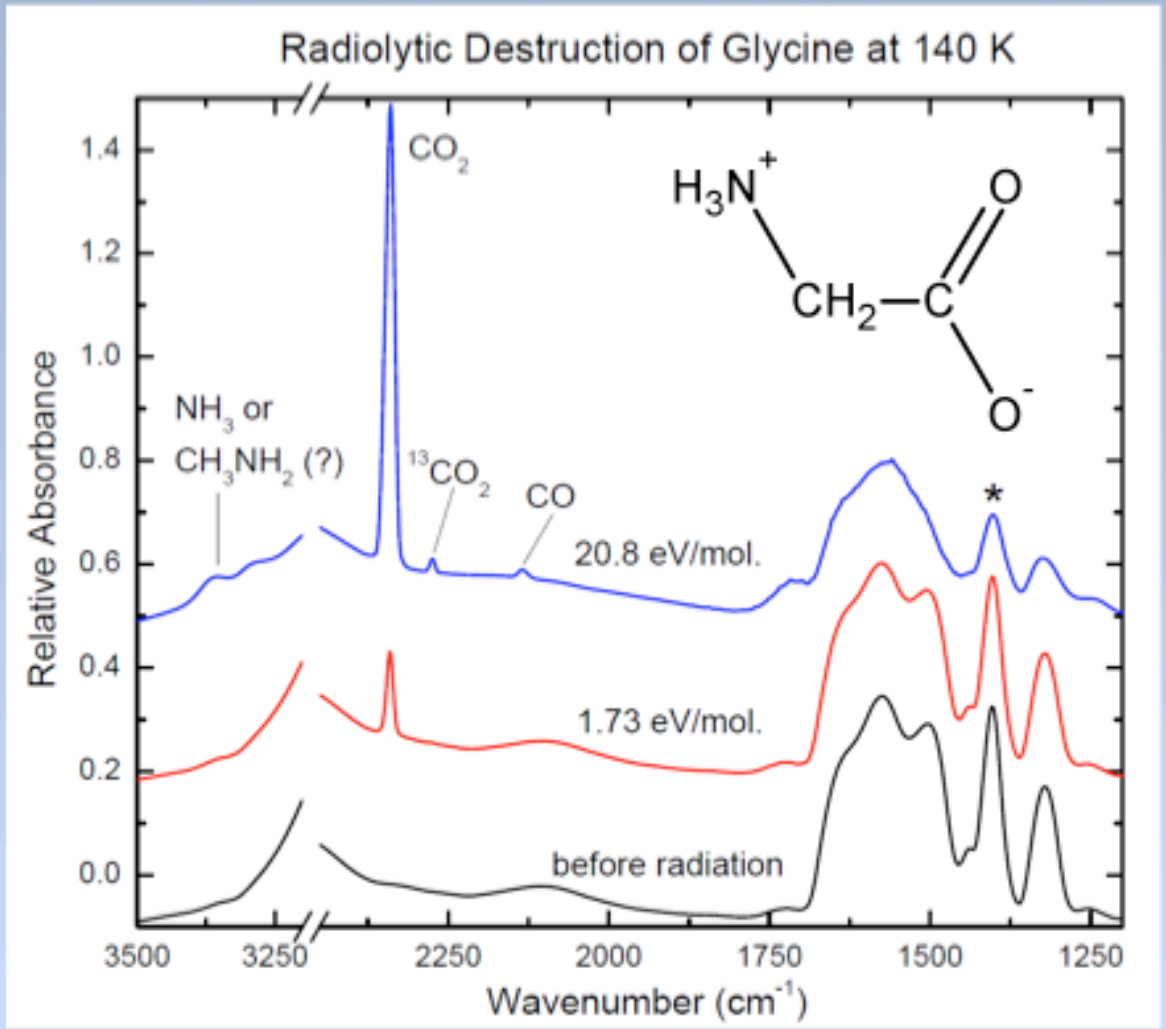
- Sublimation of glycine onto cold substrate
- Proton irradiation to simulate cosmic radiation
- Monitoring the rate of destruction by IR spectroscopy
- Sample thickness monitored with laser interferometry



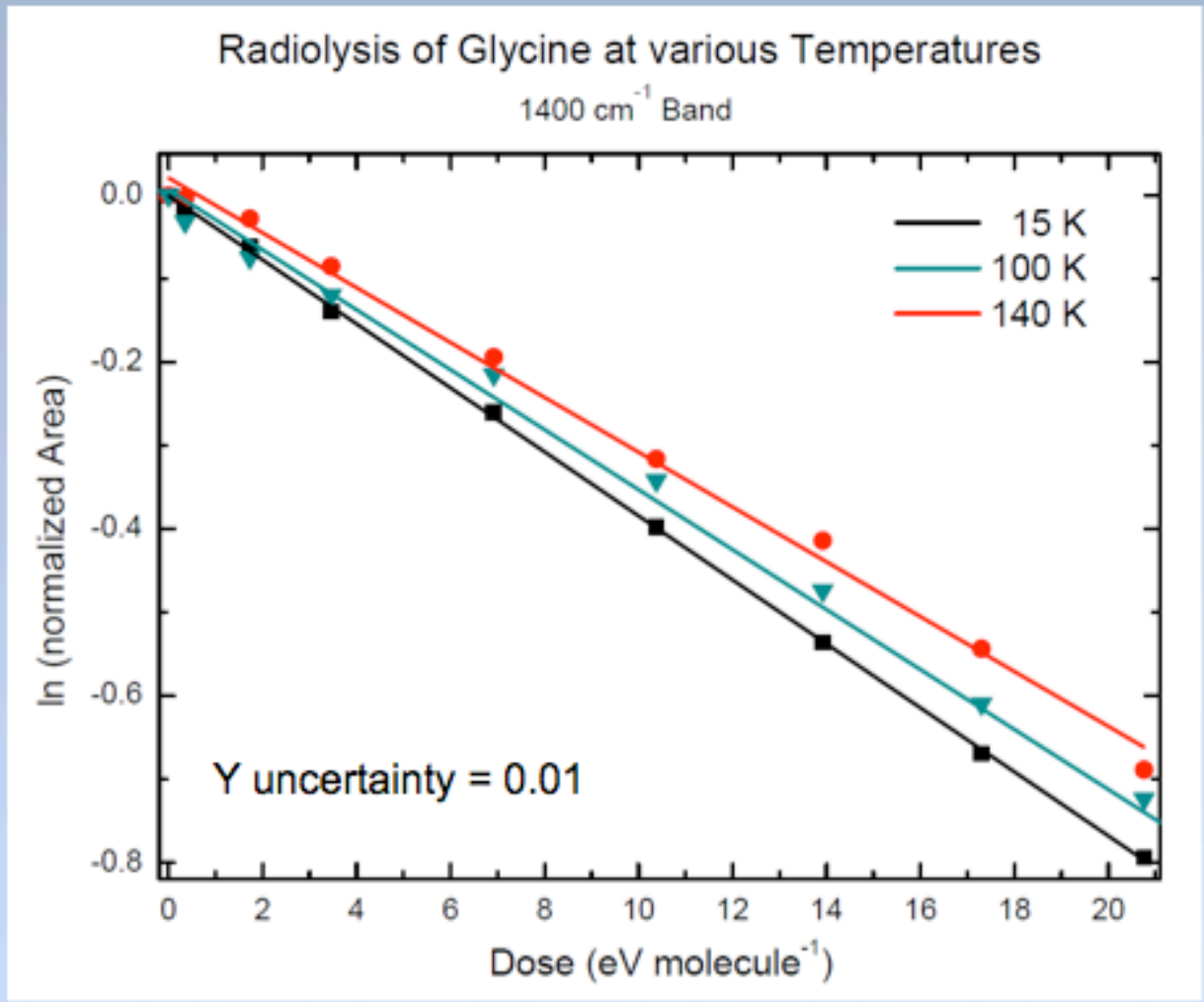
Experimental Methods



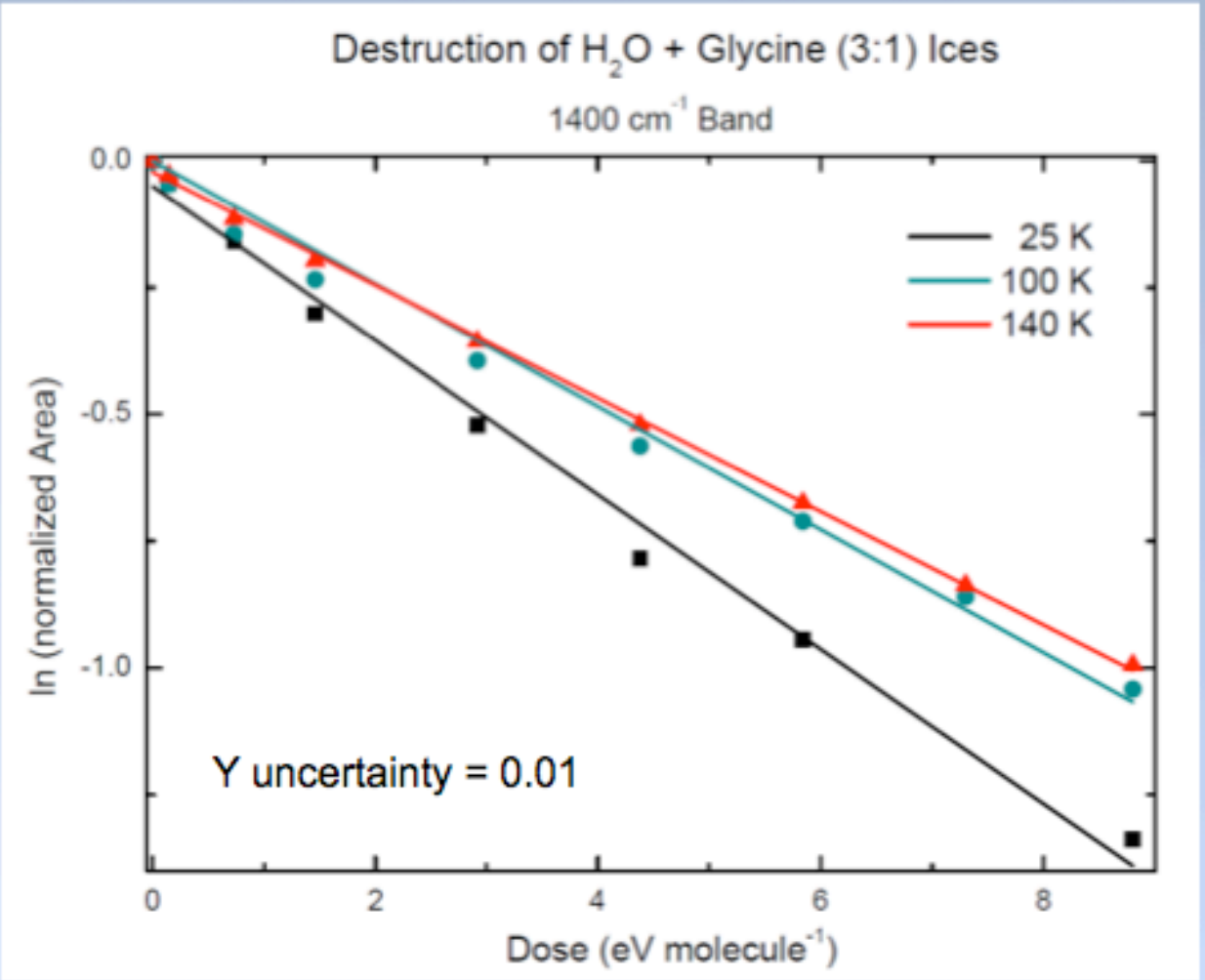
Results


Radiolytic Destruction of Glycine at 140 K
Relative Absorbance
Wavenumber (cm-1)
CO2
NH3 or
CH3NH2 (?)
13CO2
CO
20.8 eV/mol.
1.73 eV/mol.
before radiation
*
H3N+
CH2
C
O
O-
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
3500
3250
2250
2000
1750
1500
1250

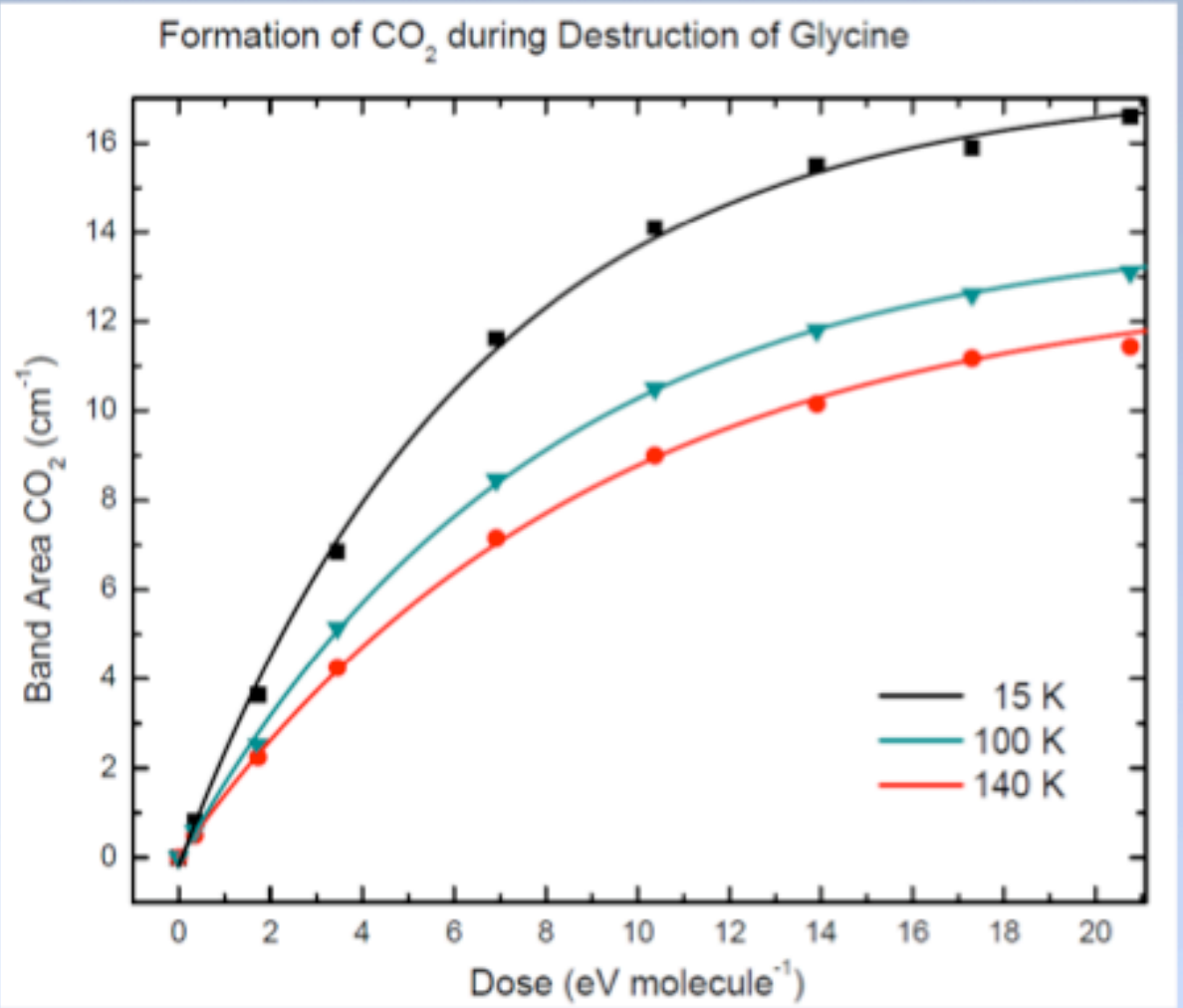
Results


Radiolysis of Glycine at various Temperatures
1400 cm-1 Band
15 K
100 K
140 K
Y uncertainty = 0.01
ln (normalized Area)
Dose (eV molecule-1)
0.0
-0.2
-0.4
-0.6
-0.8
0
2
4
6
8
10
12
14
16
18
20

Results


Destruction of H_2O + Glycine (3:1) Ices
1400 cm^{-1} Band
0.0
-0.5
-1.0
ln (normalized Area)
25 K
100 K
140 K
Y uncertainty = 0.01
0
2
4
6
8
Dose (eV $molecule^{-1}$)

Results


Formation of CO_2 during Destruction of Glycine
Band Area CO_2 (cm^{-1})
Dose (eV $molecule^{-1}$)
0
2
4
6
8
10
12
14
16
18
20
15 K
100 K
140 K

Results

Half-Life Doses (eV / molecule)

T (K)	Glycine	Water + Glycine (3:1)
15	17.9	4.21
100	21.0	5.63
140	21.6	5.99

- Faster destruction at lower temperatures between 15 - 140 K
  - Approx. 20 % slower
- Approx. 4x faster destruction in water

Results

Estimated Half-Lives of Glycine (in Years) *

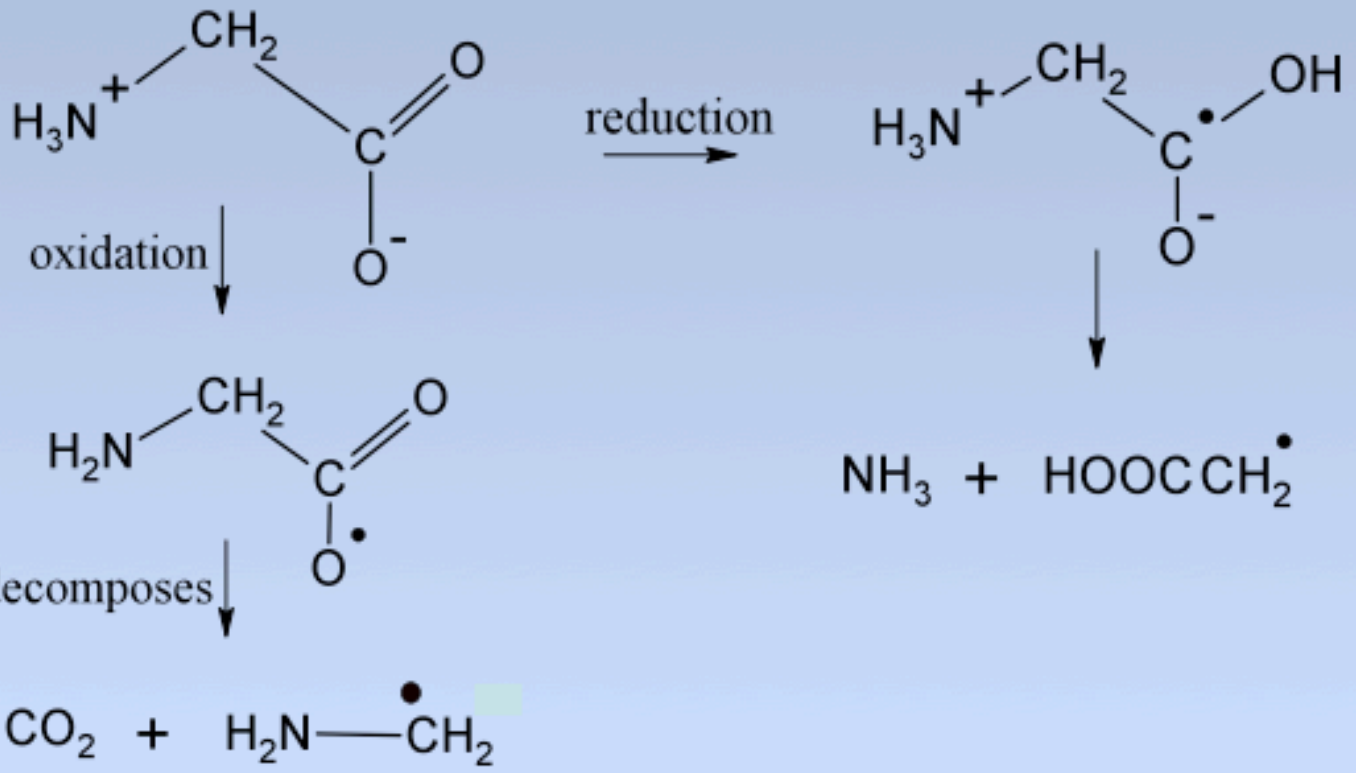
Object	$t_{1/2}$ at ~1 μm	$t_{1/2}$ at 1 m Depth
Mars	2×10^{7}	6×10^{7}
Europa	2×10^{-1}	1×10^{6}
Titan	3×10^{3}	2×10^{10}
Pluto	2×10^{8}	8×10^{8}
Oort Cloud Comet	3×10^{4}	3×10^{8}
Ice Grain in Dense Cloud	1×10^{6}	---

*Estimates are based on published dose rates

$t_{1/2}$ – time required to decompose half the glycine molecules

Conclusion

- Ionizing radiation affects the preservation of AA
- Destruction of glycine increases in the presence of water
  - Hydroxyl radical may enhance the rate of destruction

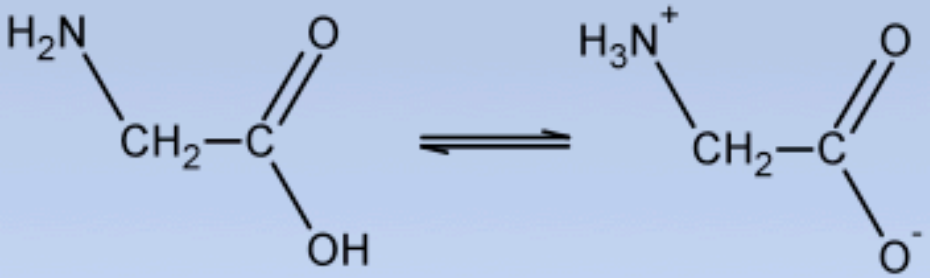


Conclusion

- Slower destruction rate of glycine at higher temperature (~20 %)

Why?

- Reformation of glycine at higher temperatures?
- Slower destruction of zwitterion which is present at higher temperatures?
  - Zwitterionic form is present at higher temperatures



Zwitterion

< ~ 100 K

> ~ 100 K

Acknowledgements

Dr. Reggie Hudson

Dr. Marla Moore

Dr. Michael Mumma

Corinne Eby

Tom Ward

Eugene Geraschenko

Goddard Center for Astrobiology

NASA

Eckerd College